Foreword

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Published online: 1 October 2015
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Until 20 years ago, nanolithography by a mechanical method was unthinkable. Not only do mechanical methods use a completely different physical principle from the traditional lithography [wave/particle interactions (e.g., photons, electrons) with matter]; but also mechanical methods were perceived, at that time, to be applicable only for large scale structures, not for nanoscale.

Twenty years ago, in 1995, nanolithography by a mechanical method was demonstrated [1]. The term “nanoimprint” or “imprint lithography” was coined. The work showed 10-nm resolution patterning with high throughput –35 times smaller than the semiconductor manufacturing node of 1995 (350 nm). The 1995 work,

together with follow-on development, started to change people’s perception of mechanical methods for nanoscale patterning, and opened up the field of nanoimprint and a paradigm shift in nanolithography [2].

Over the past 20 years, thanks to enormous innovations and contributions from the entire nanoimprint community along with government and industrial support, the field of nanoimprint has advanced enormously, making significant and unique impact on nanotechnologies and on a broad range of industries such as nanophotonics, smartphones, displays, light emitting diodes, solar cells, optical communication, semiconductor ICs, data storage, biotechnology, pharmaceuticals, medicine, and security features (banknotes, identifications), to name just a few. Nanoimprint has now grown into a multi-billion dollar industry.

From a completely new and foreign concept to today’s nanoimprint success in nanolithography, in the past 20 years, many new things have been discovered and invented and many things thought to be impossible have become possible. Who could have imagined the resolution of nanoimprint better than 0.1 nm, an imprint force no greater than pushing water, zero residue resist layer, a nanoimprinter for sub-15 nm node IC manufacturing, or printing nanostructures roll-to-roll like printing a newspaper? These wonders are just a few examples.

Of all nanopatterning technologies today, nanoimprint has been proven to have not only the highest resolution (<0.1 nm); but also a combination of high resolution, large-area (e.g. wall-paper size), pattern complexity (e.g. 3D), high-throughput, and low cost, that is unmatched by other existing methods.

At the 20 year anniversary of nanoimprint, it is our great pleasure to present you with this special journal issue on nanoimprint, which gives a glimpse of the enormous

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progress and current status of nanoimprint technology and applications.

Looking forward, clearly it is just a beginning in nanoimprint. Nanoimprint will continue to grow rapidly in academic research, making new discoveries and inventions, will exponentially grow in many industrial sectors (existing ones and future new adopters) and in revenue, and will have increasingly greater impact to modern technologies and our society. If the history of nanoimprint is any indication, we have not seen anything yet.

References

1. S.Y. Chou, P.R. Krauss, P.J. Renstrom, Imprint of sub-25 nm vias and trenches in polymers. *Appl. Phys. Lett.* **67**(21), 3114 (1995)
2. From 1974 to 1976 (20 years ahead the 1995 work), S. Fujimori and co-workers at NTT experimented with a method of embossing as lithography, and they concluded that the resolution of their method was about 1 micron and did not continue the work. Unfortunately, Fujimori's work (which is published in Japanese and in conference proceedings and Lab Reports, long before internet age) was virtually unknown until his 2009 paper that recounts his 1974 work